



New records and update on the geographic distribution of fifteen species of *Lincus* Stål, 1867 (Insecta: Hemiptera: Pentatomidae) associated with palms and coconut trees in the Neotropics

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Abstract: The Neotropical genus *Lincus* Stål, 1867 is frequently associated with the transmission of diseases to palms and coconut trees (*Elaeis guineensis* and *Cocos nucifera*) in commercial plantations in South America. Here we update the geographical distribution of 15 species of *Lincus* collected in *E. guineensis* and *C. nucifera* in the Neotropics. The geographical range of five species is expanded with new countries recorded for *L. malevolus* and *L. styliger*, and detailed geographic information is given for the first time for *L. lobuliger* and *L. securiger*.

Key words: Amazonia; *Phytomonas*; *Elaeis guineensis*; *Cocos nucifera*; hartrot; Marchitez; Ochlerini

The distribution of phytophagous insects is deeply related to the availability of vascular plants for their feeding. The insects' piercing-sucking feeding mode can be related to the transmission of many plant diseases. Among the hemipterans, insects potentially vectors of microbial plant pathogens, the heteropterans have been significantly reported as disease transmitters in the Neotropical Region. Among a diversity of plants serving as shelter and food source for many stink bugs (Pentatomidae), the coconuts and palms frequently receive microorganisms transmitted through the bugs' saliva. Diseases such as the Marchitez sorpresiva in palms (*Elaeis guineensis*) and the hartrot in coconut (*Cocos nucifera*) can affect large plantations, harming the production of a great diversity of natural products that maintain the economy in Neotropical countries, especially in the Amazon region (HOWARD 2001; ARAÚJO et al. 2003; MITCHELL 2004). The trees usually die two months after the first symptoms of the disease, which includes the progressive browning and desiccation of the leaves, rot of roots and tissues, and the drying and fall of fruits in mature plants (CAMARGO 1999; ARAÚJO et al. 2003). The

causal agent of hartrot and Marchitez is a protozoan of the family Trypanosomatidae, *Phytomonas staheli* McGhee & McGhee, 1979. This pathogen can be transmitted by pentatomids of the tribe Ochlerini as *Macropygium* Spinola, 1837, *Ochlerus* Spinola, 1837, and mainly *Lincus* Stål, 1867 (COUTURIER & KAHN 1989, 1992; CAMARGO 1999; HOWARD 2001; MITCHELL 2004; DI LUCCA et al. 2013).

Lincus, the richest ochlerine genus, was described in the 19th century (STÅL 1867) and is characterized by the presence of a long antero-lateral pronotal lobe and by characters of female and male genitalia (ROLSTON 1983; COUTURIER & KAHN 1989; HOWARD 2001). *Lincus* is distributed exclusively in the Neotropical region, already recorded in Bolivia, Brazil, Colombia, Ecuador, French Guiana, Panama, Peru, Surinam, and Venezuela. The majority of described species are from Peru (ROLSTON 1983, 1989; DOLLING 1984; COUTURIER & KAHN 1989, 1992; LLOSA et al. 1990; DOLLET et al. 1993; DI LUCCA et al. 2013; MACIEL et al. 2015; CAMPOS & ROELL 2017). *Lincus* was revised in the late 20th century by ROLSTON (1983) who provided the description of the majority of currently known species and a key to their identification. Soon after, DOLLING (1984) described two new species, *L. lethifer* and *L. apollo*, and included notes about *L. bipunctatus* (as *L. croupius*) pointing out these species as transmitters of diseases caused by tripanosomatids in coconut and palms. ROLSTON (1989) described three new species found in palms in Peru; *L. hebes*, *L. malevolus* and *L. spurcus*, and CAMPOS & ROELL (2017) described *L. curvatus* collected in palms in Ecuador. Currently, *Lincus* comprises 36 described species (ROLSTON 1983a, 1989b; DOLLING 1984; CAMPOS & GRAZIA 2006; GRAZIA et al. 2015; CAMPOS & ROELL 2017), and 15 of them have already been reported on palms and coconut trees (STAHEL 1954; DESMIER DE CHENON 1984; DOLLING 1984; LOUISE et al. 1986; RESENDE 1986; ROLSTON 1989;

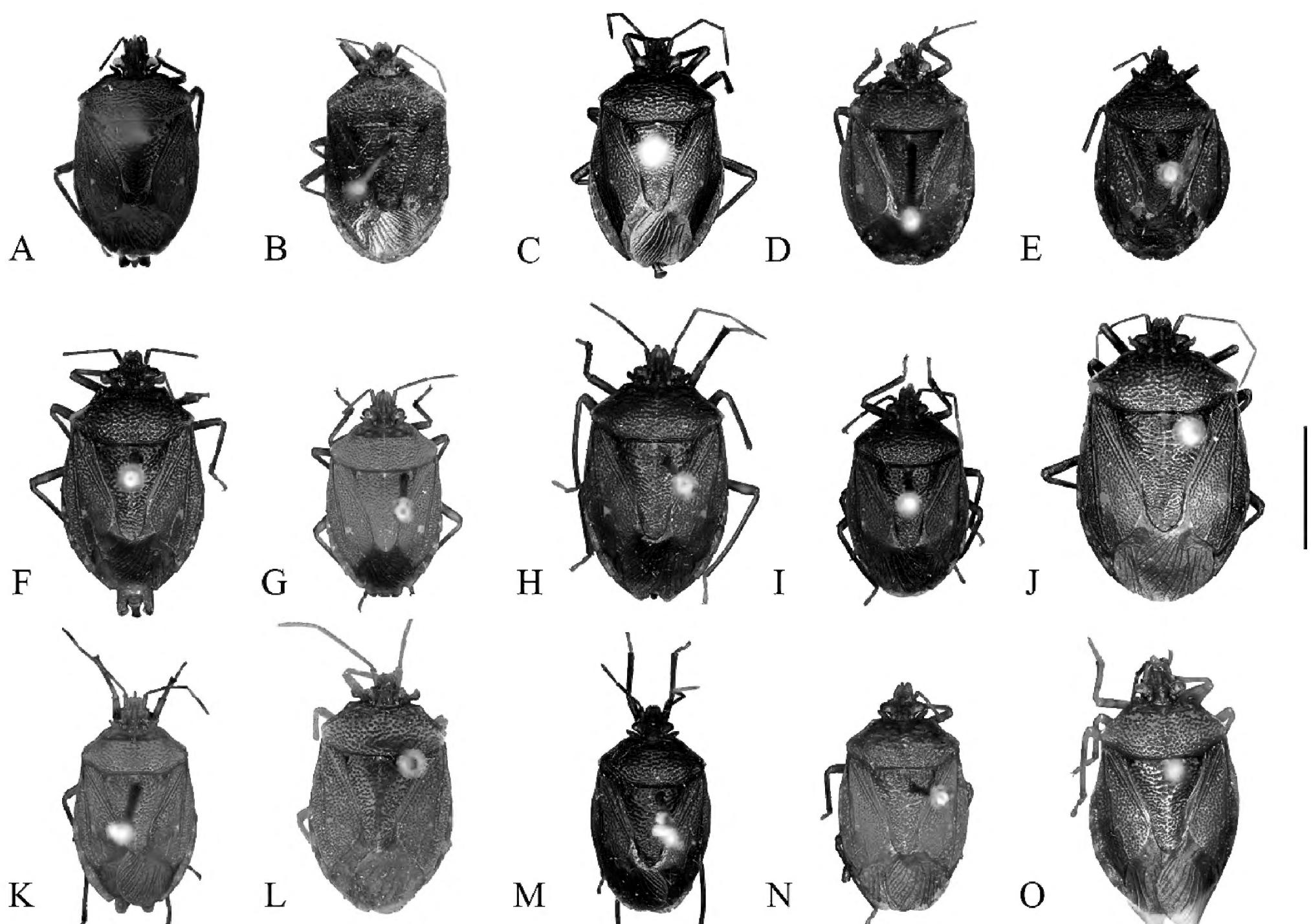


Figure 1. Species of *Lincus* associated with palms and coconut trees in the Neotropical Region, dorsal habitus. A, *L. apollo*; B, *L. bipunctatus*; C, *L. curvatus*; D, *L. dentiger*; E, *L. hebes*; F, *L. incisus*; G, *L. lethifer*; H, *L. lobuliger*; I, *L. malevolus*; J, *L. securiger*; K, *L. singularis*; L, *L. spathuliger*; M, *L. spurcus*; N, *L. styliger*; O, *L. tumidifrons*. Scale bar = 6 mm. Photos by TR (A,C), ICW (F–H, J, K, M–O). Photos received from AMNH (B), CASC (E, I), SDEI (D, L).

CAMARGO 1999; ALVES DE SOUZA 2000; PANIZZI et al. 2000; MITCHEL 2004; DI LUCCA et al. 2013; MACIEL et al. 2015; CAMPOS & ROELL 2017).

In this work we update the known distribution of the 15 species of *Lincus* that occur in palms and coconut trees. The data were reviewed from literature, and complemented by the specimen data available in the entomological collection of the Federal University of Rio Grande do Sul (UFRG), Brazil. Voucher specimens of all species with new distribution data are deposited in UFRG (numbers LES0001/16 to LES0053/16). Additionally, five males and five females of *Lincus curvatus* Campos & Roell, 2017 are deposited in the Pontificia Universidad Católica del Ecuador (PUCE) (vouchers are not numbered in this collection). We also received images of type specimens and their labels from the following collections: American Museum of Natural History, USA (AMNH); California Academy of Sciences, USA (CASC); David A. Rider collection, USA (DARC); Natural History Museum of London, United Kingdom (NHMUK); Senckenberg Deutsches Entomologisches Institut, Germany (SDEI).

The geographic coordinates are in decimal degrees and were taken from software Google Earth (version 7: <https://www.google.com/earth/>) and the map (Figure 2) was made using the software ArcGIS Desktop (version 10.4.1: <http://desktop.arcgis.com>).

***Lincus apollo* Dolling, 1984**

Figures 1A, 2, 3A; Tables 1, 2

Body brown, length between 10.2–10.9 mm, with 1 + 1 yellowish spots on humeral angles, and on apex of radial veins. Mandibular plates longer than clypeus; apex of mandibular plates and clypeus light brown, slightly translucent on apex. Pronotal lobes subtriangular, anterior margins sinuous, directed anteriorly, surpassing the lateral limit of eyes (fig. 3A, pl). Ventral rim of pygophore V-shaped, its sides straight. Segment X conical, not expanded at apex.

As mentioned by DOLLING (1984), the female of *L. apollo* runs to *L. styliger* Breddin in ROLSTON's (1983) key, but they can be differentiated by the smaller dimensions of *L. apollo*. In addition, the posterolateral angles of the pygophore are apically emarginate in *L. apollo*, and obtuse in *L. styliger*.

Distribution data (Table 2) are from DOLLING (1984). We examined the male holotype and female paratype in NHMUK to check the labels and to confirmed identification. No other specimens were available.

***Lincus bipunctatus* (Spinola, 1850)**

Figures 1B, 2, 3B; Tables 1, 2

Body brown, measuring about 10 mm, with 1 + 1 light yel-

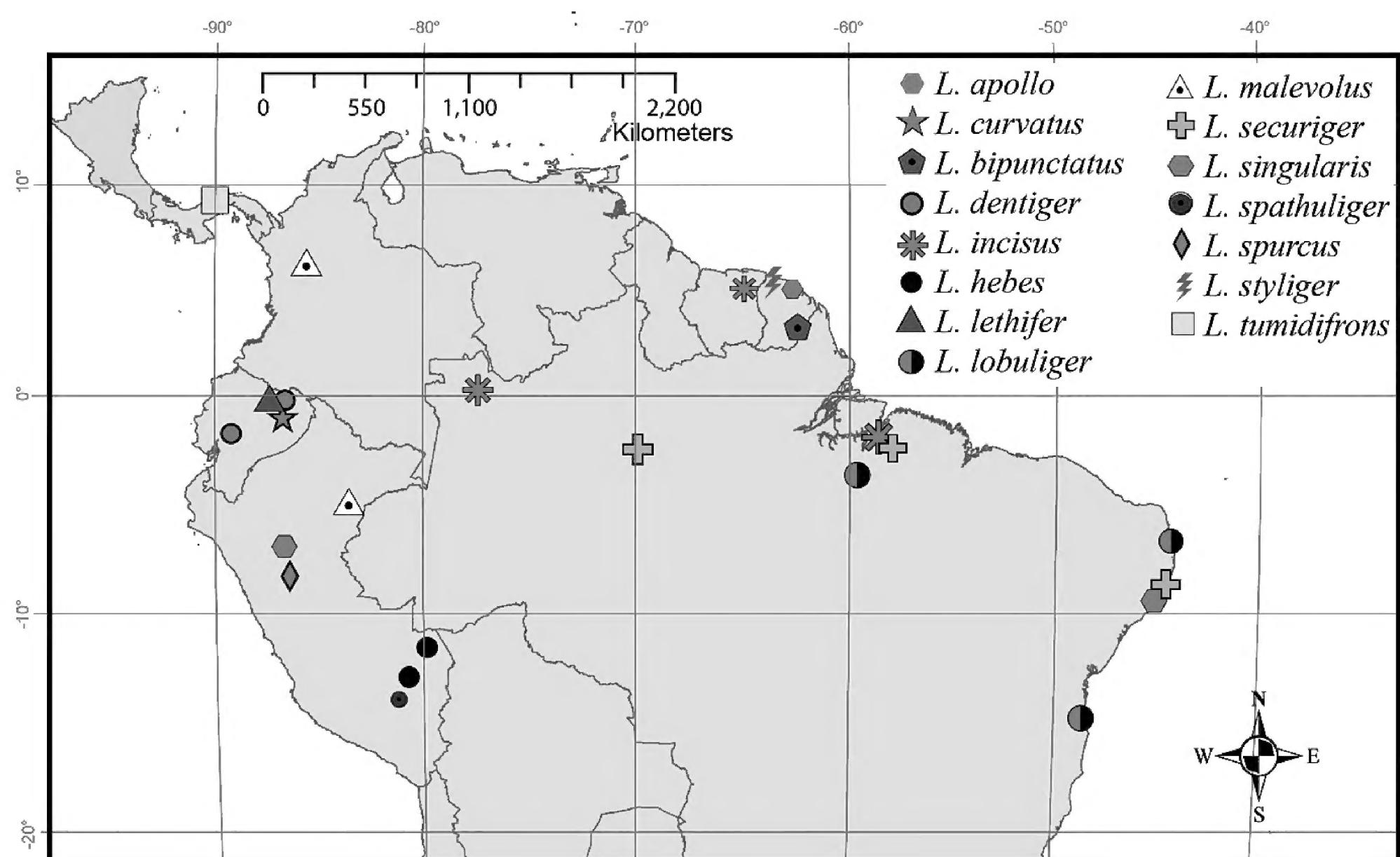


Figure 2. Geographic records of the species of *Lincus* associated with palms and coconut trees in the Neotropical Region.

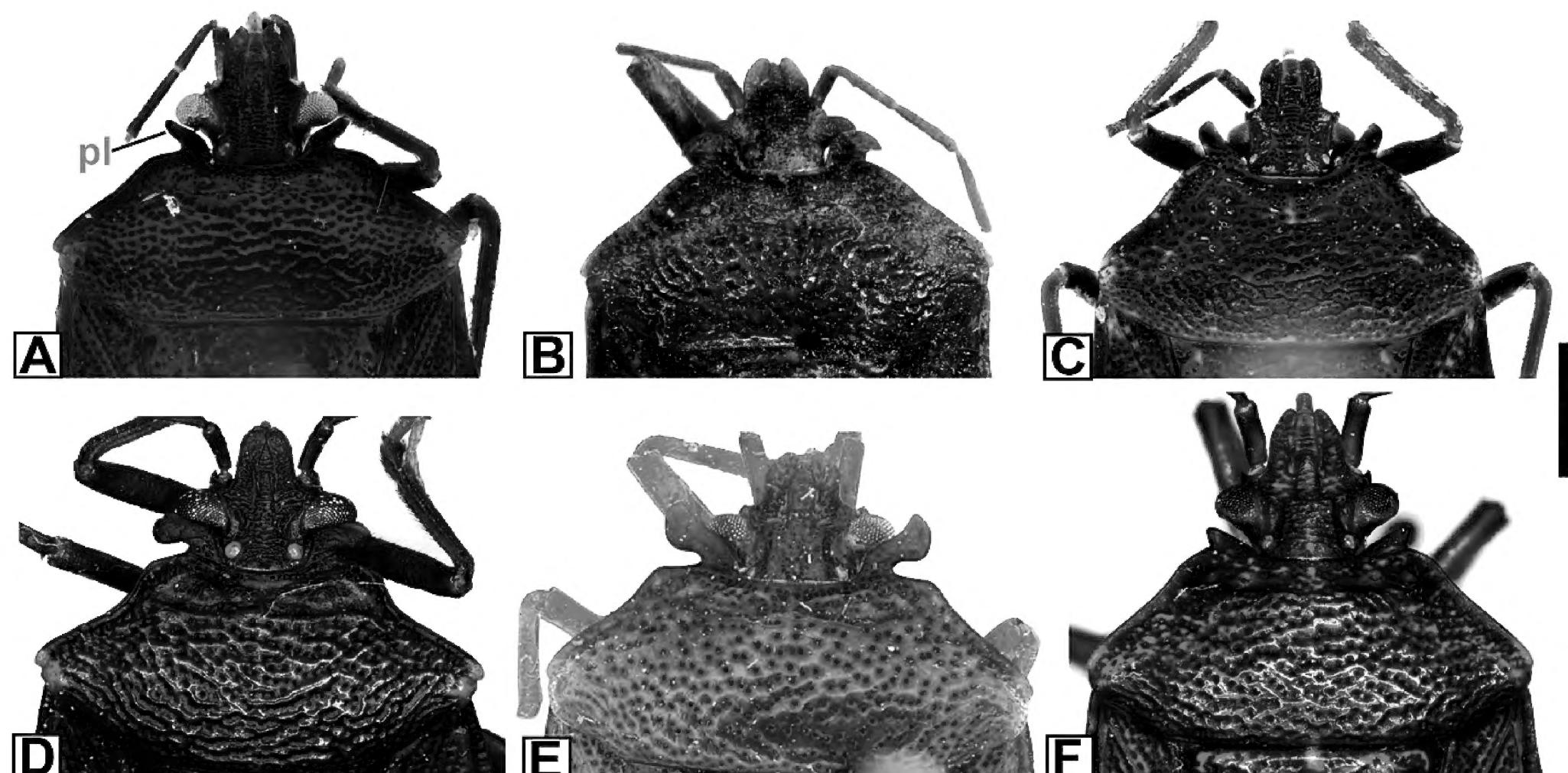


Figure 3. Species of *Lincus* associated with palms and coconut trees in the Neotropical Region, head and pronotum, dorsal. **A.** *L. apollo*. **B.** *L. bipunctatus*. **C.** *L. hebes*. **D.** *L. incisus*. **E.** *L. spathuliger*. **F.** *L. tumidifrons*. Abbreviation: pl, posterolateral angle. Scale bar = 2mm. Photos by TR (A, C), ICW (D, F). Photos received from AMNH (B), SDEI (E).

low spots on apex of radial veins. Distal two antennomeres, labium and tarsi yellowish. Mandibular plates slightly longer than clypeus, not convergent. Pronotal lobes broad, deflexed toward apex, surpassing the lateral limit of eyes about one-half width of each eye, anterior margins convex (Fig. 3B). Ventral rim of pygophore V-shaped, setose, and

sinuous in profile (ROLSTON 1983, figs. 13 and 14).

Lincus bipunctatus is included in ROLSTON's (1983) key as *L. croupius* Rolston. This species was compared to *L. fatigus* Rolston by ROLSTON (1983) because both have deflected pronotal lobes; however, the pronotal lobes of *L. bipunctatus* are broad and convex anteriorly, while in *L.*

Table 1. List of the species of *Lincus* associated with palms and coconut trees in the Neotropical Region.

Species	Host Plant	References
<i>Lincus apollo</i> Dolling, 1984	Coconut	Dolling 1984; Camargo 1999; Mitchell 2004
<i>Lincus bipunctatus</i> (Spinola, 1850)	Coconut	DESMIER DE CHENON 1984; DOLLING 1984; DOLLET et al. 1993; CAMARGO 1999; MITCHELL 2004
<i>Lincus curvatus</i> Campos & Roell, 2017	Palm	CAMPOS & ROELL 2017
<i>Lincus dentiger</i> Breddin, 1904	Coconut	CAMARGO 1999; MITCHELL 2004
<i>Lincus hebes</i> Rolston, 1989	Palm	ROLSTON 1989; LLOSA et al. 1990
<i>Lincus incisus</i> Rolston, 1983	Coconut	MACIEL et al. 2015
<i>Lincus lethifer</i> Dolling, 1984	Coconut and palm	DOLLING 1984; PERTHUIS et al. 1985; DOLLET et al. 1993; MITCHELL 2004
<i>Lincus lobuliger</i> Breddin, 1908	Palm	CAMARGO 1990; DOLLET et al. 1993; MITCHELL 2004
<i>Lincus malevolus</i> Rolston, 1989	Palm	ROLSTON 1989; LLOSA et al. 1990
<i>Lincus securiger</i> Breddin, 1904	Coconut	ALVES DE SOUZA et al. 1999
<i>Lincus singularis</i> Rolston, 1983	Palm	MACIEL et al. 2015
<i>Lincus spathuliger</i> Breddin, 1908	Palm	MITCHELL 2004
<i>Lincus spurcus</i> Rolston, 1989	Palm	ROLSTON 1989; LLOSA et al. 1990; DI LUCCA et al. 2013; MACIEL et al. 2015
<i>Lincus styliger</i> Breddin, 1908	Coconut	DESMIER DE CHENON 1984; MITCHELL 2004
<i>Lincus tumidifrons</i> Rolston, 1983	Palm	DOLLET et al. 1993; MITCHELL 2004

fatigus they are expanded apically with sinuous anterior margins (ROLSTON 1983, figs. 10 and 16).

Distribution data (Table 2) are from ROLSTON (1983) and DOLLING (1984).

***Lincus curvatus* Campos & Roell, 2017**

Figures 1C, 2, 4A; Tables 1, 2

Body dark brown, measuring about 9.88–10.68 mm, with 1 + 1 light yellow spots on apex of radial veins. Mandibular plates slightly longer than clypeus, not convergent. Pronotal lobes spatulate, rounded, surpassing the lateral limit of eyes. Membrane of corium arcuate in males (CAMPOS & ROELL 2017, fig 6A). Ventral rim of pygophore V-shaped, bearing setae. Segment X quadrangular and membranous at base, projected posteriorly and ventrad in cylindrical shape, spatulate with rounded expansion at apex. The segment X curves to the right (Fig. 4A, X).

As mentioned by CAMPOS & ROELL (2017), this species can be misidentified as *L. lamelliger* Breddin or *L. subuliger* Breddin in ROLSTON's (1983) key; however, *L. curvatus* can be distinguished by the the asymmetrical segment X of males.

Distribution data (Table 2) are from CAMPOS & ROELL (2017).

***Lincus dentiger* Breddin, 1904**

Figures 1D, 2, 4I; Tables 1, 2

Body brown, measuring between 9.50–10.00 mm, yellow spotted on humeral angles, base of pronotum and scutellum, apex of each radial vein, and on the centre of each connexival segment. Mandibular plates slightly longer than clypeus, not convergent. Pronotal lobes subtriangular, anterior margin straight, lateral directed, slightly surpassing the lateral limit of eyes. Laterotergites IX subtriangular. Ventral rim of pygophore lyre-shaped, with setae along the margin (Fig. 4I, vr).

Lincus dentiger is included in ROLSTON's (1983) key, identified on step 28 through characteristics of male genitalia, or on step 32 through characteristics of the pronotal

lobes. Besides that, this species is included in the “big-eyed” convenience group (ROLSTON 1983) along with *L. breddini* Rolston, *L. lamelliger*, *L. laminatus* Rolston, *L. lobuliger* Breddin, *L. rufospilotus* (Westwood), *L. styliger*, *L. substyliger* Rolston and *L. vallis* Rolston. The main difference between *L. dentiger* and the other species of this group is the lyre-shaped ventral rim of phygophore.

We examined the labels of the female holotype through images received from SDEI. In addition, we examined one female in the collection of UFRG, which is from a new locality in Ecuador.

***Lincus hebes* Rolston, 1983**

Figures 1E, 2, 3C; Tables 1, 2

Body dark brown, measuring about 9.20–11.30 mm, yellow stained on humeral angles, discal corium, and on middle of each connexival segment. Mandibular plates slightly longer than clypeus, not convergent, vertex of head slightly tumescent. Eyes small, width of each eye no more than half of interocular distance. Pronotal lobes subrectangular, apically expanded, truncate, anterior margins straight, surpassing the lateral limit of eyes more than width of each eye (Fig. 3C) (ROLSTON 1989). Ventral rim of pygophore V-shaped, with setae along the margin, medially carinated. Segment X expanded, longer than pygophore, apex rounded (ROLSTON 1989, figs. 1, 2, 3 and 4).

Lincus hebes was described after the review of *Lincus* (ROLSTON 1983) and placed in the “little eyed” convenience group (ROLSTON 1983, 1989). Although this species runs to *L. armiger* Breddin in Rolston's key, these two species can be distinguished by the pronotal lobes: rectangular in *L. hebes* and digitiform in *L. armiger*.

We examined the labels of a male paratype through images from CASC. We also examined two specimens at UFRG from the same locality as the paratype.

***Lincus incisus* Rolston, 1983**

Figures 1F, 2, 3D; Tables 1, 2

Body dark brown, measuring between 12.55–12.80 mm,

Table 2. Distribution records for the species of *Lincus* associated with palms and coconut trees in the Neotropical Region. New collection sites located in previously registered countries or states/provinces are referred to as “new locality”, whereas new collection sites located in also new registered countries or states/provinces are referred to as “new record”.

Species	Previous distribution records	Latitude	Longitude	References	New distribution records	Latitude	Longitude	Notes	
<i>Lincus apollo</i> Dolling, 1984	French Guiana: Cayenne, Kourou	5.1600	-52.6605	Dolling 1984					
<i>Lincus bipunctatus</i> (Spinola, 1850)	French Guiana: Camopi French Guiana: Kourou Brazil: Amapá, Rio Pelioaca (exact site unknown)	3.1653 5.1617	-52.3426 -52.6488	ROLSTON 1983, DOLLING 1984					
<i>Lincus curvatus</i> Campos & Roell, 2017	Ecuador: Orellana, El Coca, Palmar del Rio	-0.2861	-77.1016	CAMPOS & ROELL 2017					
<i>Lincus dentiger</i> Breddin, 1904	Surinam (exact site unknown) Ecuador, Balazpamba		-0.2441	78.5347	ROLSTON 1983	Ecuador: Sucumbíos, Shushufindi, 1 female (UFRG)	-0.1827	-76.6390	New locality
<i>Lincus incisus</i> Rolston, 1983	Surinam: Blaka-Watra Brazil: Amazonas, São Miguel da Cachoeira, Cachoeira do Tucano Pará, Moju, Fazenda Socôco	5.4143 0.3261 -1.8845	-54.9286 -67.5539 -48.7658	ROLSTON 1983 MACIEL et al. 2015					
<i>Lincus hebes</i> Rolston, 1983	Peru: Madre de Dios, Puerto Maldonado Peru: Mazuco	-11.8282 -13.0914	-69.9518 -70.3659	ROLSTON 1989					
<i>Lincus lethifer</i> Dolling, 1984	Ecuador: Sucumbíos, Shushufindi	-0.1827	-76.6390	DOLLING 1984; DOLLET et al. 1993					
<i>Lincus lobuliger</i> Breddin, 1908	Brazil: Bahia; Espírito Santo; Rio de Janeiro (exact locality unknown)			ROLSTON 1983	Brazil: Pará, Tucuruí, 1 male (UFRG) Brazil: Paraíba, Lucena, 2 males and 3 females (UFRG)	-3.7658 -6.9032	-49.6772 -34.8749	New records	
<i>Lincus malevolus</i> Rolston, 1983	Peru: Loreto, Maynas Peru: Jenaro Herrera Peru: Requena	-3.1565 -4.9053 -5.0615	-73.4010 -73.6708 -73.8558	ROLSTON 1989, LLOSA et al. 1989	Colombia: Antioquia, Medellín, 1 male (UFRG)	6.2544	-75.5685	New record	
<i>Lincus securiger</i> Breddin, 1904	Peru, Bolivia, Brazil (exact localities unknown)			ROLSTON 1983	Brazil: Amazonas, Manaus, 1 male and 2 females (UFRG) Brazil: Pará, Tucuruí, 1 male Brazil: Pará, Moju, Fazenda Socôco, 7 males and 4 females Brazil: Alagoas, Maceió, 2 males and 3 females	-2.6244 -3.7892 -1.8845 -9.6489	-60.0508 -49.7798 -48.7658 -35.7155	New localities	
<i>Lincus singularis</i> Rolston, 1983	Peru: Cauchamayo; San Martín, Palmas del Espino S.A	-8.4033	-76.4099	ROLSTON 1983, MACIEL et al. 2015					
<i>Lincus spathuliger</i> Breddin, 1908	Peru: Marcapata	-13.5900	-71.0001	ROLSTON 1983					
<i>Lincus spurcus</i> Rolston, 1989	Peru: Saposoa. Peru: San Martín, Tocache Peru: Uchiza	-6.9353 -8.1632 -8.4166	-76.7711 -76.5438 -76.4166	ROLSTON 1983; LLOSA et al. 1989; DI LUCCA et al. 2013					
<i>Lincus styliger</i> Breddin, 1908	Colombia. Peru (collection sites unknown)			ROLSTON 1983	French Guyane: Mana, Saut Sabbat, 1 male and 1 female (UFRG)	5.3902	-53.6719	New record	
<i>Lincus tumidifrons</i> Rolston, 1983	Panama: Barro Colorado Panama: Cabima Panama: Las Cumbres Panama: Chepo Colombia. Venezuela (collection sites unknown)	9.1518 9.1361 9.0875 9.1653	-79.8458 -79.5340 -79.5469 -79.0983	ROLSTON 1983; DOLLET et al. 1993					

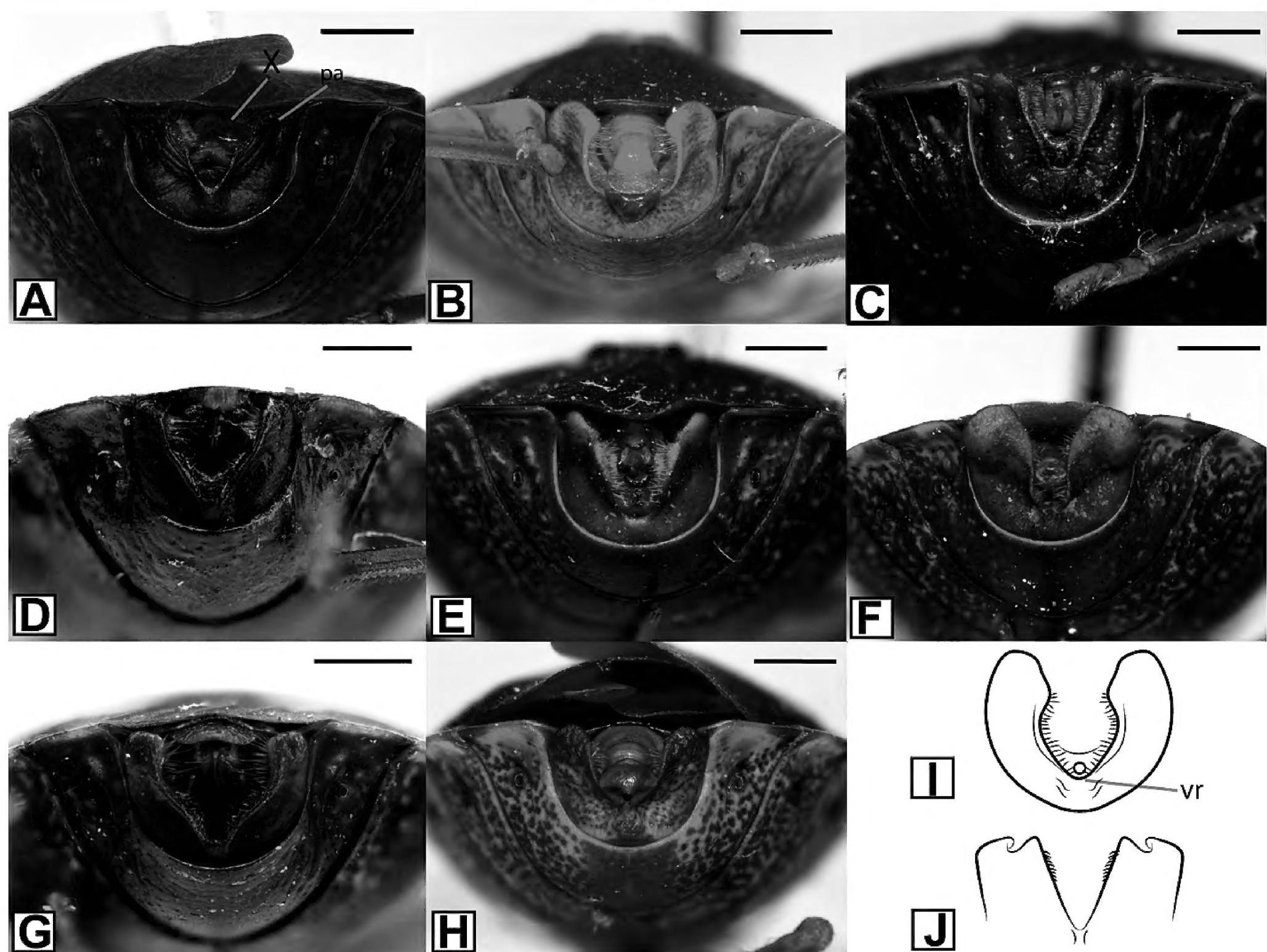


Figure 4. Species of *Lincus* associated with palms and coconut trees in the Neotropical Region, pygophore, posterior view. **A.** *L. curvatus*. **B.** *L. lethifer*. **C.** *L. lobuliger*. **D.** *L. malevolus*. **E.** *L. securiger*. **F.** *L. singularis*. **G.** *L. spurcus*. **H.** *L. tumidifrons*. **I.** *L. dentiger*. **J.** *L. styliger*. Photos by TR (A); I.C. Winter (B–H). Photos received from CASC (D). Figures I and J are from ROLSTON (1983). Scale bars = 2 mm.

yellow stained on humeral angles, base and apex of scutellum, apex of each radial vein and on middle of each connexival segment. Mandibular plates longer than clypeus, convergent. Eyes large, width of each eye more than half of the interocular distance. Pronotal lobes apically expanded, hatchet-shaped, surpassing the lateral limit of eyes (Fig. 3D) (ROLSTON 1983). Pygophore subrectangular, ventral rim concave with setae along the margin, medially carinated. Apex of segment X expanded and flattened (MACIEL et al. 2015, figs. 11 and 12).

Lincus incisus is included in ROLSTON's (1983) key. Recently, the male of *L. incisus* was described by MACIEL et al. (2015) who presented new distribution records for the species.

***Lincus lethifer* Dolling, 1984**

Figures 1G, 2, 4B; Tables 1, 2

Body ocher to dark brown, measuring between 9.70–10.60 mm, basal half of head and pronotum darker than apex, three yellow spots on base of scutellum, 1 + 1 on apex of each radial vein, and one on middle of each connexival segment. Mandibular plates slightly longer than clypeus, not

convergent. Pronotal lobes subtriangular, longer than wide, surpassing the lateral limit of eyes (DOLLING 1984, fig. 1). Ventral rim of pygophore U-shaped, with a medial obtuse projection at level of apex of segment X. Segment X globular, expanded, deflexed and spatulated apically (Fig. 4B) (DOLLING 1984, fig. 2). Gonocoxites 8 tetragonal (DOLLING 1984, fig. 4).

Lincus lethifer was compared to *L. anulatus* Rolston by DOLLING (1984) who claimed the shape of gonocoxites 8, tetragonal in *L. lethifer* and rounded in *L. anulatus*, is sufficient to distinguish the two species.

Distribution data (Table 2) are from DOLLING (1984) and DOLLET et al. (1993).

***Lincus lobuliger* Breddin, 1908**

Figures 1H, 2, 4C; Tables 1, 2

Body dark brown, measuring between 9.40–12.00 mm, yellow stained on humeral angles, apex of each radial vein, and on middle of each connexival segment. Mandibular plates longer than clypeus, not convergent. Pronotal lobes subtriangular, longer than wide, surpassing the lateral limit of eyes, anterior margins straight. Ventral rim of pygophore

U-shaped, with setae on $\frac{1}{3}$ apical, medially carinated. Segment X tubular, apex flattened, not expanded, posteriorly directed (Fig. 4C).

Lincus lobuliger is included in ROLSTON's key (1983) and placed in the "big-eyed" convenience group (ROLSTON 1983). The characteristics that distinguish this species from the others in this group are: mandibular plates not convergent (convergent in *L. vallis*); pronotal lobes longer than wide and surpassing the lateral limit of eyes (not surpassing in *L. breddini*, and as long as wide in *L. lamelliger*); ventral rim of pygophore U-shaped (V-shaped in *L. dentiger*, *L. laminatus*, and *L. styliger*), and pygophore subrectangular (oval in *L. rufospilotus* and *L. substyliger*).

Through the examination of the specimens in the collection of UFRG we expand the distribution of *L. lobuliger* to two states in Brazil (Pará and Paraíba) and one new locality in the state of Bahia, Brazil.

***Lincus malevolus* Rolston, 1989**

Figures 1I, 2, 4D; Tables 1, 2

Body dark brown, measuring between 9.60–11.30 mm, with one yellow spot on base of pronotum, one on base of scutellum, and 1 + 1 on apex of each radial vein. Mandibular plates little longer than clypeus, not convergent. Pronotal lobes digitiform, rounded at apex, anterior margins straight, anterolateral directed, surpassing the lateral limit of eyes. Ventral rim of pygophore V-shaped, with setae along the margin, medially carinated (Fig. 4D). Apex of parameres visible from posterior view. Segment X subrectangular, moderately expanded, but not surpassing the postero-lateral angles (ROLSTON 1989, figs. 12–14).

ROLSTON (1989) compared *L. malevolus* to *L. spurcus* Rolston by the similar coloration and general morphology, indicating the male genitalia as the best character to differentiate them. The ventral rim of pygophore is more straight in *L. malevolus* than *L. spurcus*, and the segment X is more expanded in *L. spurcus* than *L. malevolus*.

Through the examination of the specimens in the collection of UFRG we expand the distribution of *L. lobuliger* to a new record for Colombia.

***Lincus securiger* Breddin, 1904**

Figures 1J, 2, 3E; Tables 1, 2

Body dark brown, measuring between 12.60–12.80 mm, yellow stained on humeral angles, base of scutellum, apex of each radial vein, and on middle of each connexival segment. Mandibular plates little longer than clypeus, not convergent. Pronotal lobes expanded, hatchet-lobed, surpassing the lateral limit of eyes about 1/2 width of each eye (ROLSTON 1983, fig. 25). Ventral rim of pygophore V-shaped, with setae on the apical third, medially carinated. Segment X tubular, not expanded (Fig. 3E) (ROLSTON 1983, figs. 26–29).

Lincus securiger is included in ROLSTON's (1983) key, distinguished from *L. convexus* Rolston on the ninth step. Through the examination of 20 specimens in the collection

of UFRG we expand the known distribution of *L. securiger* to new localities in the states of Alagoas, Amazonas and Pará, Brazil.

***Lincus singularis* Rolston, 1983**

Figures 1K, 2, 4F; Tables 1, 2

Body dark brown to fuscous, measuring between 10.75–12.60 mm, with 1 + 1 yellow spots on apex of each radial vein, and one on middle of each connexival segment. Mandibular plates little longer than clypeus, not convergent. Pronotal lobes subtriangular, anterior margins straight, antero-laterally directed, surpassing the lateral limit of eyes (ROLSTON 1983, fig. 34). Postero-lateral angles of pygophore rounded, ventral rim V-shaped with setae along margin. Segment X not expanded, lateral margins sinuous (Fig. 4F) (MACIEL et al. 2015, figs. 2, 3). Lateral angles of gonocoxites 8 strongly produced, projecting on laterotergites 8 (ROLSTON 1983, fig. 35).

Lincus singularis is included in ROLSTON's (1983) key and is identified on the twelfth step. The female genital plates are quite distinct from the other *Lincus* species, showing gonocoxites 8 with produced lateral margins, while in other species of *Lincus* the lateral margins of gonocoxites 8 are straight. The pygophore is also peculiar, with postero-lateral angles rounded and dorsally depressed, distinctly projected beyond the ventral rim.

Distribution data (Table 2) are from ROLSTON (1983) and MACIEL et al. (2015).

***Lincus spathuliger* Breddin, 1908**

Figures 1L, 2, 3E; Tables 1, 2

Body castaneous, measuring about 11.00 mm, yellow stained on humeral angles, on apex of radial veins, and on middle of each connexival segment. Mandibular plates little longer than clypeus, slightly convergent. Pronotal lobes strongly expanded, hatchet-lobed, surpassing the lateral limit of eyes more than width of each eye (Fig. 3E). Male unknown. Posterior margins of gonocoxites 8 obtusely angled.

Lincus spathuliger was compared to *L. vandoesburgi* Rolston by ROLSTON (1983) because it has expanded pronotal lobes and short second antennomeres. The difference between the two species is the absence of a subapical projection on the anterolateral pronotal margins in *L. spathuliger*, present in *L. vandoesburgi*.

Distribution data (Table 2) are from ROLSTON (1983).

***Lincus spurcus* Rolston, 1989**

Figures 1M, 2, 4G; Tables 1, 2

Body castaneous to dark brown, measuring between 9.01–10.80 mm, slightly yellow stained on humeral angles and on apex of radial veins. Mandibular plates little longer than clypeus, not convergent. Pronotal lobes digitiform with a rounded apex, anterior margins straight, lateral directed, surpassing the lateral limit of eyes. Ventral rim of pygophore lyre-shaped, carinated, and with setae along margin.

Segment X expanded, but not surpassing the postero-lateral angles (Fig. 4G) (ROLSTON 1983, figs. 9–11).

ROLSTON (1989) put this species in the “little eyed” convenience group (ROLSTON 1983). *Lincus spurcus* can be differentiated from the other species in this group by the straight and laterally directed anterior margin of pronotal lobes (antero-laterally directed in *L. armiger*), pronotal lobes surpassing the lateral limit of eyes by $\frac{1}{2}$ the width of each eye (not surpassing in *L. discessus* (Distant) and *L. modicus* Rolston; slightly surpassing in *L. leviventris* Rolston and *L. varius* Rolston), laterotergites 9 subtriangular (rounded in *L. armiger*), and ventral rim of pygophore lyre-shaped (U-shaped in *L. discessus*, *L. manchus* Rolston, *L. modicus* and *L. repizcus* Rolston; V-shaped in *L. varius*).

Distribution data (Table 2) are from ROLSTON (1983), LLOSA et al. (1989) and DI LUCCA et al. (2013).

***Lincus styliger* Breddin, 1908**

Figures 1N, 2, 4J; Tables 1, 2

Body castaneous, measuring between 11.50–12.50 mm, with 1 + 1 yellow spots on apex of radial veins. Mandibular plates little longer than clypeus, slightly convergent. Pronotal lobes digitiform with apex rounded, surpassing the lateral limit of eyes by no more than $\frac{1}{2}$ the width of each eye (ROLSTON 1983, fig. 94). Ventral rim of pygophore V-shaped, medially carinated, with setae on $\frac{1}{3}$ apical (Fig. 4J). Segment X tubular, not expanded (ROLSTON 1983, figs. 97 and 99).

Lincus styliger is included in ROLSTON’s (1983) key, being differentiated from *L. laminatus* Rolston by differences in the male genitalia, and from *L. dentiger* by differences in the pronotal lobes. *Lincus styliger* is included in the “big-eyed” group of convenience (ROLSTON 1983), but can be distinguished from the other species of this group by the pronotal lobes surpassing the lateral limit of eyes (not surpassing in *L. breddini*), pronotal lobes longer than wide (as long as wide in *L. lamelliger*), and ventral rim of pygophore V-shaped (U-shaped in *L. breddini*, *L. lobuliger*, *L. rufospilotus*, *L. substyliger*, and *L. vallis*; lyre shaped in *L. dentiger*). A new distribution record of *L. styliger* in French Guiana is presented in this work.

***Lincus tumidifrons* Rolston, 1983**

Figures 1O, 2, 3F, 4H; Tables 1, 2

Body fuscous to brown, measuring between 11.00–13.70 mm, stained in yellow. Mandibular plates little longer than clypeus, lateral margins sigmoid. Vertex of head tumescent. Pronotal lobes small, subtriangular, in line or little surpassing the lateral limit of eyes (Fig. 3F) (ROLSTON 1983, fig. 36). Ventral rim of pygophore V-shaped, carinated, with setae along margin. Segment X expanded, posteriorly directed (Fig. 4H) (ROLSTON 1983, figs. 39–41).

Lincus tumidifrons is included in ROLSTON’s (1983) key. The species is placed in the “swollen head” convenience group (ROLSTON 1983) along with *L. parvulus* and *L. singularis*. The species can be distinguished by pronotal lobes

subtriangular in *L. tumidifrons* while rounded in *L. parvulus* and *L. singularis*. The female and male genitalia are also distinctive in *L. tumidifrons* in comparison with *L. parvulus* and *L. singularis*.

Distribution data (Table 2) are from ROLSTON (1983) and DOLLET et al. (1993), and from labels of two paratypes from Panama in DARC.

This is the first compilation of the geographic distribution of the *Lincus* species recorded on palm and coconut trees, since the first reports associating the genus with the transmission of *Phytomonas* were published in the 1980s (e.g., DESMIER DE CHENON 1984; COUTURIER & KHAN 1989). The previous list accounting for 11 species of *Lincus* collected on palm and coconut trees (HOWARD 2001) is updated to the 15 species identified here. The geographical ranges of five species are expanded with new countries recorded for *L. malevolus* and *L. styliger*, representing a linear range expansion of 1,200 and 1,500 km respectively. Also, detailed geographic information has been retrieved for *L. lobuliger* (new records in Pará and Paraíba, Brazil) and *L. securiger* since these species were previously referred only generically to their presence in the respective countries of occurrence. Both *L. lobuliger* and *L. securiger* have the largest distribution ranges among the species studied, occurring in the Brazilian Amazon and Atlantic Forest regions.

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LITERATURE CITED

ALVES DE SOUZA, L., A.B. SILVA, P.M.P. LINS & A.A. MÜLLER. 1999. Biologia de Ochlerus sp. (Heteroptera: Pentatomidae), possível vetor da doença “hartrot” em coqueiro. Boletim de Pesquisa, 24. Belém: Embrapa Amazônia Oriental. 15 pp.

ARAÚJO, J.C.A., J.C.R. PEREIRA & L. GASPAROTTO. 2003. Murchado-Phytomonas do coqueiro no Amazonas. Circular Técnica n. 17, Embrapa, Manaus, Amazonas, Brazil.

BREDDIN, G. 1904. Neue Rhynchotenausbeute aus Sud-Amerika. Societas Entomologica 18(20): 153–154.

Breddin, G. 1908. Beiträge zur Systematik der Pentatomiden Südamerikas. Zweites Stück. Sitzungsberichte der Gesellschaft Naturforschender Freunde zu Berlin 1908: 24–36.

CAMARGO, E.P. 1999. Phytomonas and other tripanosomatid parasites of plants and fruit. Advances in Parasitology 42: 29–112. doi: 10.1016/S0065-308X(08)60148-7

CAMPOS, L.A. & J. GRAZIA. 2006. Análise cladística e biogeografia de Ochlerini (Heteroptera, Pentatomidae, Discocephalinae). Iheringia, Série Zoologia 96(2): 147–163. doi: 10.1590/S0073-47212006000200004

CAMPOS, L.A. & T. ROELL. 2017. Description of four new species of Ochlerini from South America (Hemiptera: Pentatomidae: Discocephalinae). Zootaxa. doi: 10.11646/zootaxa.4236.3.5

COUTURIER, G. & F. KAHN. 1989. Bugs of *Lincus* spp. vectors of marchitez

and hartrot (oil palm and coconut diseases) on *Astrocaryum* spp., amazonian native plants. *Principes* 33(1): 19–20.

COUTURIER, G. & F. KAHN. 1992. Notes on the insect fauna on two species of *Astrocaryum* (Palmae, Cocoeae, Bactridinae) in Peruvian Amazonia, with emphasis on potential pests of cultivated palms. *Bulletin de l'Institut Français d'Études Andines* 21(2): 715–725.

DESMIER DE CHENON, R. 1984. Recherches sur le genre *Lincus* Stål, Hemiptera Pentatomidae Discocephalinae, et son rôle éventuel dans la transmission de la Machitez du palmier à huile et du Hart-Rot du cocotier. *Oléagineux* 39(1): 1–6.

DI LUCCA, A.G.T., E.F.T. CHIPANA, M.J.T. ALBÚJAR, W.D. PERALTA, Y.C.M. PIEDRA & J.L.A. ZELADA. 2013. Slow wilt: another form of marchitez in oil palm associated with trypanosomatids in Peru. *Tropical Plant Pathology* 38(6): 522–533. doi: 10.1590/S1982-56762013000600008

DOLLET, M., F. ALVANIL, A. DIAZ, C. LOUVET, D. GARGANI, C. SEGUR, E. MULLER, J.F. JULIA, H. CALVACHE, J.L. RENARD & J.M. MALDES. 1993. Les pentatomides vecteurs des trypanosomes associés au hartrot du cocotier et marchitez du palmier. In: *Annales de la 3ème Conférence Internationale sur les Ravageurs en Agriculture*, Montpellier 7–8–9 Décembre 1993, Tome III, 1321–1328.

DOLLING, W.R. 1984. Pentatomid bugs (Hemiptera) that transmit a flagellate disease of cultivated palms in South America. *Bulletin of Entomological Research* 74(3): 473–476. doi: 10.1017/S000748530001573X

GRAZIA, J., A.R. PANIZZI, C. GREVE, C.F. SCHWERTNER, L.A. CAMPOS, T.A. GARBELOTTO & J.A.M. FERNANDES. 2015. Stink Bugs (Pentatomidae); pp. 681–756, in: PANIZZI, A.R. & J. GRAZIA (eds.). *True bugs (Heteroptera) of the Neotropics, entomology in focus*, vol. 2. Dordrecht: Springer Netherlands. doi: 10.1007/978-94-017-9861-7_22

HOWARD, F.W. 2001. Insect pests of palms and their control. *Pesticide Outlook* 12: 240–243. doi: 10.1039/B110547G

LLOSA, J.F., G. COUTURIER & F. KAHN. 1990. Notes on the ecology of *Lincus spurcus* and *L. malevolus* (Heteroptera: Pentatomidae: Discocephalinae) on palmae in forests of Peruvian amazonia. *Annales de la Société Entomologique de France* 26(2): 249–254.

MACIEL, A.S., T.A. GARBELOTTO, I. WINTER, T. ROELL & L.A. CAMPOS. 2015. Description of the males of *Lincus singularis* and *Lincus incisus* (Hemiptera: Pentatomidae: Discocephalinae). *Zoologia* 32(2): 157–161. doi: 10.1590/S1984-46702015000200007

MC GHEE, R.B. & A.H. MC GHEE. 1979. Biology and structure of *Phytomonas staheli* sp. n., a trypanosomatid located in sieve tubes of coconut and oil palms. *The Journal of Protozoology* 26(3): 348–351. doi: 10.1111/j.1550-7408.1979.tb04633.x

MITCHELL, P.L. 2004. Heteroptera as vectors of plant pathogens. *Neotropical Entomology* 33(5): 519–545. doi: 10.1590/S1519-566X2004000500001

PANIZZI, A.R., J.E. MCPHERSON, D.G. JAMES, M. JAVAHERY & R.M. MCPHERSON. 2000. Economic importance of stink bugs (Pentatomidae); pp. 421–474, in: C.W. SCHAEFER & A.R. PANIZZI (eds.). *Heteroptera of economic importance*. Boca Raton: CRC Press.

PERTHUIS, B., R. DESMIER DE CHENON & E. MERLAND. 1985. Mise en évidence du vecteur de la Marchitez sorpresiva du palmier à huile, la punaise *Lincus lethifer* Dolling (Hemiptera Pentatomidae Discocephalinae). *Oléagineux* 40(10): 473–476.

ROLSTON, L.H. 1983. A revision of the genus *Lincus* Stål (Hemiptera: Pentatomidae: Discocephalinae: Ochlerini). *Journal of the New York Entomological Society* 91(1): 1–47.

ROLSTON, L.H. 1989. Three new species of *Lincus* (Hemiptera: Pentatomidae) from palms. *Journal of the New York Entomological Society* 97(3): 271–276.

SPINOLA, M. 1837. *Essai sur les genres d'insectes appartenants à l'ordre des Hémiptères Lin. ou Rhyngotes, Fab. et à la section Hétéroptères*. Geneve: Dufour Y. Gravier. 383 pp.

SPINOLA, M. 1850. *Dialcunigenere id in setti artroidignati nuovamente proposti dal socio attuale Signor Marchese Massimiliano Spinola nella sua tavola sinottica di questo ordine che precede la presente memoria. Memorie della Società Italiana delle Scienze residente in Modena* 25(1): 61–138.

STÅL, C. 1867. *Bildrag till Hemipterernas systematik. Conspectus generum Pentatomidum Americae. Öfversigt af Kongliga Vetenskaps-Akademiens Förfärlingar* 24(7): 522–532.

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